South American Development Society Journal

Vol.: 08, | Nº.: 24 | **Ano:** 2022 | **ISSN:** 2446-5763 | **DOI:** 10.24325/issn.2446-5763.v8i24p182-202
Data de Submissão: 15/07/2022 | **Data de Publicação:** 22/012/2022

CITY-AS-A-SERVICE: A DESIGN FRAMEWORK FOR SMART CITIES

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In science fiction literature of the 1950s and 1960s, the reader is frequently presented to a concept of a futuristic city enclosed by an all-encompassing “dome” that shelters its dwellers from a hostile environment, while providing them the comfort and infrastructure needed to develop a safe and productive community. These domes are no longer fiction: they already exist, invisible, enabled by the wireless Internet infrastructure that surrounds and supports most of the contemporary urban activities.

Called “Smart City” by commercial enterprises, media and marketing departments, the fully connected metropolis risks being anything but. It is undeniable that the digitization of metropolitan infrastructures is both desirable and needed, but the way it may be performed demands consideration.

Beyond data and analytics, smart city information and communications technologies approaches need to tap into the organic flows that make up a living city. This research believes it is the most effective way to turn cities into serviceable interfaces for urban development, with people at the heart of the process. The Digital revolution is less about the physical matter of cities and more about how the infrastructure and its inhabitants will communicate with each other.

Such transformation is, of course, much easier said than done. Both cities and their populations are immense and hugely complex networks, with a plethora of specific demands. Digitization is to be understood as an evolutive process, never to be considered fully accomplished[1]. The framework proposed in this research aims to understand how to leverage the three main stakeholders balancing city life: People, Government and Business ventures.

The framework proposed in this research is devised to provide urban operating systems with interface properties that enable the general public with ubiquitous and easy access to city data in a human-readable way, through interactive graphic interfaces. To be efficient and truly usable, these interfaces should require minimal or no technical expertise to use, therefore stimulating its manipulation and the development of new, creative proposals in a rich environment that resembles a social network or game. The idea is to access the collective intelligence which may emerge of a multitude of small interactions in a truly democratic environment. It already exists; it just needs to become palpable.

The citizen's right to the digital city

Cities nowadays provide an environment that is far from engaging. The overall crises and a growing income inequality are leading to a greater gentrification, which means, in many cases, the privatization of public areas, that become more fortresses than places of heterogeneous humanity, because they are meant only for specific classes of people. One class to be served, the other to be surveilled and contained.

The citizen's right to the digital city strengthens the role of cities in a deliberative democracy. Private investment may shape cities, but social theories and laws are what shape private investments. First comes the image of what is wanted, then the machinery is adapted to turn out that image. The financial machinery has been adjusted to create anti-city images mostly because societies believed this would be good for its inhabitants. This mindset is now changing, being replaced by the idea of lively, diversified communities, capable of continual, networked improvements; and the financials are gradually being adjusted to this new reality.

[1] See KELLY (2010, loc. 624) for more about the infinite goals of technology.

In the following years, a transformation will change the way the physical world is perceived. Sensors, robots, and personal fabrication will create a dynamic structure, closer to 'mother nature', with its multitude of variables distributed among resilient and interdependent networks[2] than to the doped imprisonment, elective or coerced to a frequently surveilled environment.

Beyond data and analytics, smart city ICT approaches need to tap into the organic flows that make up a living city. They can turn cities into serviceable interfaces for urban development, with people at the heart of the process. This revolution is less about the physical matter of cities and more about how the infrastructure and its inhabitants will communicate with each other. Any aspect characterizing a user interface has to be built open to modification, adapting the user interface in its: presentation—the perceivable aspects, including media and interaction techniques, layout, graphical attributes; dynamic behavior— including navigation structure, dynamic activation, and deactivation of interaction techniques; and content—including texts, labels, and images.

Collective Intelligence

Getting smart city solutions to work on their citizens' behalf is, therefore, more complex than just developing and applying technology to the existing infrastructure. It demands new networking and management competencies that are yet undefined. A possible way to achieve them is to set up and manage projects with different stakeholders and expectations, in multidisciplinary teams with specialists like psychologists and ethnographers on the team. It is a practice that, despite having a good chance of being more inclusive, can't eliminate all cultural biases. These days there are better ways to devise open and transparent systems that harness the emergent collective intelligence of the environment. A smart city can only be worth its title when it also enables their inhabitants to become smarter. Fostering creativity and consensus decision making helps to develop social capital while reaping the opportunities that arise from the synergies created from frequent interactions among networks, databases, public administration, intelligence agents and the general population. Among them are stronger feedback and faster, suppler responses to unexpected situations, which can help to speed up and enhance decision processes.

[2] BARABÁSI (2002, p. 246) uses network theory to explain the formation, growth and resilience of complex structures.

Many online endeavors have shown that there is much to be gained from transparent public structures. They can be used to build relationships, disarm strangers, defuse myths of perfection, neutralize stigmas, organize social groups, and protect public structures[3]. Most of all, by being welcome to greater understanding and collaboration, they foster the citizens' ability to understand the macro structures that public services are integrated to.

Researchers at Massachusetts Institute of Technology's Center for Collective Intelligence[4] explore the intelligence emergent from groups of people and computers. Their main goal is to understand how they can be connected in a way that, collectively, they end up acting more intelligently than any individual, group, or computer alone. Among their discoveries on the factors that promote collective intelligence is that, among crowds, diversity usually trumps ability. That led to the development of an equation called Diversity Prediction Theorem[5], in which:

Crowd Error = Average Individual Error – Diversity Among Individuals

According to this proposition, the best way to reduce errors would be to keep the crowd as diverse as possible. For it is possible to collapse the difference between crowd error and average individual error by forcing little or no difference among individuals. Improving the collective intelligence of city institutions, with emphasis placed on citizen participation may help everyone involved to learn, adapt and promptly respond to changing circumstances in daily life.

When considering that a single person tends to make decisions motivated by self-preservation, collective intelligence can be a better way of solving problems. This happens because the solutions proposed won't come from singular answers, but instead from pluralistic, networked, and ongoing approaches, in which groups interact locally, trying to figure out what's the best solution for current problems, then providing directions and orchestrating action.

Of course, such strategies are not perfect. Critics like Blau (1970)[6] contend that a

[3] JARVIS, Jeff (2011, loc. 102)
[4] Their website (appropriately, a Wiki) can be reached at <http://scripts.mit.edu/~cci/HCI/>
[5] Available at < https://scripts.mit.edu/~cci/HCI/index.php?title=Main_Page#Diversity > retrieved at Oct 7, 2022
[6] BLAU, Peter M. (1970): *A Formal Theory of Differentiation in Organizations,* American Sociological Review, Vol. 35, No.2 (Apr., 1970), pp. 201-218. Available at < https://www.jstor.org/stable/2093199?seq=1#page_scan_tab_contents > retrieved at Oct 7, 2022

main barrier to collaboration may be the difficulty in achieving agreement when diverse viewpoints exist. Tom Atlee[7] reflects that, although humans have an innate ability to gather and analyze data, they are affected by culture, education and social institutions.

City-as-a-Service

What is a city for? The public arenas in which most human and institutional interactions happens is, since the Greek polis and the Roman civitas, the most suitable places for human interaction. The Greek word is the root for words like metropolis and cosmopolitan, while the Latin word generated civilization and citizenship. But nowadays the public arena is being relocated from the plazas to the Internet Cloud in such a certain way that makes most cities lose their meaning.

Like markets, cities are emerging bodies that are born, grow and die because of the quality of the services provided[8]. In a world increasingly collaborative, cities are becoming action enablers, and their integrated urban infrastructures resemble a single, dynamic and tunable service. It is, therefore, fundamental to investigate to whom the city interfaces speak, who it excludes, why are them excluded, and how the situation can be reversed.

City data is commonly regarded to specialists, according to an old belief that holds the average citizen as someone incapable and not interested in dealing with infrastructure issues. This bigoted, technocratic affirmation tends to split society between castes regarding their access to knowledge. Its outcome is predictable: most urban technologies focus on changing how things are done, but often not whether the process is fair, scalable or even open to reforms.

The planning, management and construction of future cities requires an integrated approach. Despite being rather evident, this approach is still rather uncommon, for there have been few systemic approaches to city management. Like traditional industries business models, most city administrations still follow the “pipeline” model[9], in which resources are aggregated for service provision, then delivered to

[7] Atlee, T. (2008): *Reflections on the evolution of choice and collective intelligence.* Available at < http://www.newmediaexplorer.org/tom_atlee/2008/05/15/reflections_on_the_evolution_of_choice_and_collective_intelligence.htm > retrieved at Oct 7, 2022

[8] BARABÁSI (2002, p. 79) explains the growth of markets following the principles of network theory.

[9] CHOUDARY (2015, loc. 26) develops an extensive comparison between the pipeline model of traditional industries and what he calls a “platform” scale of new, collective businesses.

customers. Value is produced upstream and consumed downstream, in a linear flow.

The emerging design of business is changing, though. Some of the fastest-growing businesses of the last decade —Google, Facebook, Apple, Uber, Airbnb to name a few— are sometimes called platforms, for they create plug-and-play infrastructures that enable stakeholders to connect and interact with each other in an egalitarian manner, something that wasn't possible until recently.

In platforms citizens become co-managers. The structure does not create the end value, but it enables value creation. As a result, all participants take on production as well as consumption roles. When the structure cannot entice users to act and engage consistently, it is unlikely to be successful at creating value. In this model, scale is no longer achieved purely through accumulation of labor and resources within a business or through non-scalable contractual relationships outside it. Instead, it tends to be achieved by leveraging interactions within the ecosystem.

Some of the most successful examples of this value creation can be seen in collective ventures like Wikipedia. The online encyclopedia allows anyone to contribute content to a self-policing/semi-autonomous editorial base that works together to create a constantly changing document on the platform. Similarly, Waze, an Israeli traffic prediction app, crowdsources driving information from multiple drivers while simultaneously using algorithms to determine authenticity before distributing traffic conditions to the wider community. In both examples, a dead end is seen as an opportunity to edit and increase value and resilience to the network.

Mental models

A smart city will be of little value to most of its inhabitants unless they can learn how to use the new technologies at their disposal. Very few people, however, can pull live data from an Application Programing Interface or set up a sensor network. Whether municipal, commercial or citizen-generated, data only becomes understandable and usefully actionable when designed, displayed in carefully considered cartography, iconography, typography and language.

The compatible, machine-readable data generated by sensors and networks in smart city proposals is mostly invisible or illegible to the layperson. To make matters worse, it is most of the times hidden or privately-held. Even when it is said to be open,

its databases can be unimaginably big, inaccessible and/or complex. And the impacts of slightly changing any of its many variables are often subtle, indirect and dynamic. One of the major roles of design is to transform data into stories, models, and principles that can be easily understood and shared. Models are used in the natural and social sciences to represent complex phenomena with abstractions. Good ones highlight the salient features of the structures and relationships they represent and understate less significant details.

People understand and interact with systems and environments based on mental representations developed from experience. These models are appropriately called mental models. Design uses psychology-derived concepts[10] to try to define the ways in which one understands and interacts with systems and environments by comparing the outcomes of their mental models with real-world results. When the outcomes agree, the mental model is said to be accurate.

Since the design should be developed with users in mind, it is essential to try to understand and visualize the salient aspects of their relationships with each other; what they want with their social and physical environments; and their intended goals with the products designed. Regarding design, two basic types of mental models prevail: the ones that try to understand how systems work (system models) and the ones attempting to define how people interact with systems (interaction models)[11].

Traditional manufacturing processes generally display rather complete and accurate system models, but often develop weak interaction models. This usually results in knowing much about how a system works, but little about how people will interact with it.

Conversely, product and service users tend to have sparse and inaccurate system models, but through usage and experience they frequently attain interaction models that are completer and more accurate than those of designers. Optimal design today generally happens when designers have an accurate and complete system model, attain an accurate and complete interaction model that enable then to build system interfaces reflecting an efficient merging of both models.

[10] The seminal works on mental models are CRAIK (1943) and JOHNSON-LAIRD (1983).
[11] For a design perspective, see YOUNG, Richard: Surrogates and Mappings: Two Kinds of Conceptual Models for Interactive Devices and NORMAN, Donald: Some Observations on Mental Models, both in GENTNER & STEVENS (1983).

Customizable products may speed up this process by enabling end users to customize their products by choice, instead of having to adapt to new official hardware or software updates. The popularity of some consumer industries, like amateur photography, bicycling and desktop PCs derived in part from the fact that users could buy an entry-level device and upgrade and customize them at will.

Interaction models should also be open-ended. As soon as an expertise level is achieved, new challenges tend to arise, in a growing complexity. When the design of services with interaction models in mind is not possible, (e.g., the system is new and novel). It is regarded as a good practice to create an interaction experience drawing from common mental models, such as desktop metaphor for computers.[12]

Personas and user journeys

One of the most effective ways to develop relevant user interaction mental models is to build behavior archetypes, called personas. They provide an accurate way[13] of thinking and communicating about hypotheses on how groups of users behave, how they think, what they want to accomplish, and why. Personas are not real people, but composite archetypes from the behaviors and motivations researched, formalized in charts for better defining product design.

The usual train of thought to develop a service aiming to satisfy a diverse range of users is to make its functionality as broad as possible, accommodating most needs. This logic, however, is rather flawed. When a product's functionality is too broadly extended to include many constituencies, the result can lead to the increase of the cognitive load and navigational overhead for almost all. User experience specialist agree[14] that the best way to successfully accommodate a variety of users is to design for specific types of individuals with specific needs.

[12] Derivative objects (icons, windows, screen backgrounds etc.) that retain ornamental design cues from structures that were in the original are called skeuomorphs. They appear in various realms, like pottery with imitation rivets reminiscent of metal. They are common in software that mimics the appearance of common items, like paper desk calendars or film cameras. Despite their easy recognition, interactions with computer devices are mostly cultural and learned, therefore it is considered better to have users learning a new, clear and consistent model, than to use a familiar one that does not fit or can become easily outdated. They also tend to take up more screen space than standard interface elements, usually breaks operating system interface design standards, can easily lead to an inconsistent look and feel between applications, can increase cognitive load with visual noise and can limit creativity by grounding the experience to its physical counterpart. Donald Norman, one of the leading interaction designs, calls them "Cultural Conventions" that lead to "Cultural Constraints" at < https://jnd.org/affordances_and_design/ >. All retrieved on September 6, 2022.

[13] For more about Personas see COOPER et. at. (2014, loc. 154)

[14] Almost every book on User Experience deals with personas. Institutional sources like the website *usability.gov* recommend their usage < https://www.usability.gov/how-to-and-tools/methods/personas.html > and many academic papers also deal with the importance of the technique, like CANOSSA & DRACHEN (2009), available at < http://www.digra.org/wp-content/uploads/digital-library/09287.49165.pdf > and BLOMQUIST & ARVOLA (2002), available at < https://dl.acm.org/doi/10.1145/572020.572044 > all links retrieved on Oct 7, 2022

The interaction of every persona is simulated in user journeys, usually represented by a series of steps, building a scenario in which a user might interact with the product or service devised. Personas can be used for demonstrating the way users currently interact with a product or service or the way they can interact in a future implementation.

According to COOPER et al (2014)[15], there are many benefits to user journeys:

> Demonstrating the vision for the project – a simple way to communicate what the service is trying to achieve with their stakeholders. Along with personas they can be one of the key outputs at the beginning of a project;
> Helping to identify functionalities at a high level – by understanding the key tasks used and what functional requirements will help to enable them;
> Helping to understand user behavior – by splitting the interaction process, user journeys can help to work out how users are going to interact with the system and what they expect from each part of it; and
> Helping to define interface taxonomy – in understanding the task flows of various users they ease the developing of taxonomies that help support those tasks and what kind of interfaces the user will be needing to accomplish them.

The same authors[16] state that before attempting a user journey it is important to understand the user's goals; their motivations; their current problems; and the main tasks they want to achieve.

In each step of the journey, it is also important to consider its:

> **Context** – where the user is; what is around; external factors which may be distracting;
> **Progression** – how does each step enables the next;
> **Devices used** – features and level of expertise or expert;
> **Functionalities expected** – and whether they are achievable; and
> **Emotion** – user's emotional state in each step.

Of all aspects, the harder and most intangible variable to quantify is emotion; for it is quite subjective. There are, though, methods to gain a general overview on user's emotions.

Emotional Journeys

Published findings in neuroscience indicate it is emotion, not reason that primarily

[15] COOPER et al (2014, loc. 115)
[16] Id. Ibid, loc. 126.

drives users' decisions, with emotion stimulating the mind faster[17] than rational thought. Delivering the right messages at the right time also helps to stimulate considerations along user journeys[18].

Too frequently the user experience process is focused on the rational rather than the emotional, meaning that the features presented in each screen tend to be considered early in the development process, while the positioning, layout and wording of individual buttons and fields regarded to a later phase. This is a waste of opportunities, for visual and media elements can have a large impact on conversion rates.

But measuring emotional engagement right is not easy, and it usually requires large and expensive processes. It is possible, however, to simulate this measurement resorting to techniques like Robert Plutchik's wheel of emotions[19], which attempts to identify eight different primary emotions (in the center), with polar opposites and different intensities and combinations of each.

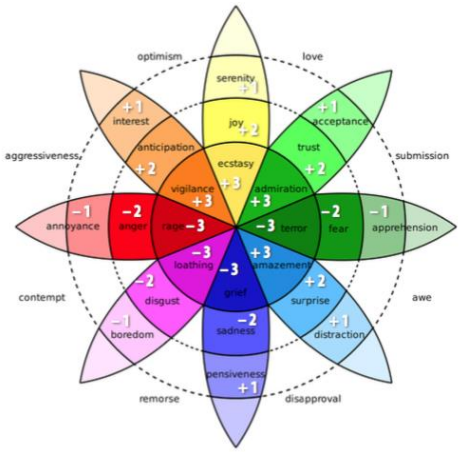

Figure 1: Robert Plutchik's wheel of emotions[20]

Using Plutchik's model, emotions in the central circle can be worth three points —either negative or positive— those on the second circle, two points; and so on, due to

[17] Among the many studies on the subject, Aldo Rustichini's article *Emotion and Reason in Making Decisions*, published in *Science* (09 Dec 2005: Vol. 310, Issue 5754, pp. 1624-1625), available at < https://www.science.org/doi/10.1126/science.1122179 > retrieved on Oct 7, 2022; and Richard D. Lane's 1999 book *Cognitive Neuroscience of Emotion*,Oxford University Press, give a clear overview on the subject.

[18] In Digital Marketing, a *Conversion funnel* is the consumer journey through an Internet service until the digital service's main goals are achieved. The metaphor of a funnel is used to describe the decrease in numbers that occurs at each step of the process. Many books deal with the subject, like Tim Frick's 2010 *Return on Engagement: Content, Strategy, and Design Techniques for Digital Marketing*, Taylor & Francis.

[19] Robert Plutchik's *The Nature of Emotions* (2001) is a study on the theory behind the wheel of emotions published by The American Scientist Journal, and can be found at < https://www.americanscientist.org/issues/feature/the-nature-of-emotions > retrieved on Oct 2, 2022.

[20] Picture from *WikiCommons*. Public Domain. Available at < https://en.wikipedia.org/wiki/Emotion_classification#/media/File:Plutchik-wheel.svg >

their different intensities. When applied earlier in the process of defining user journeys, this technique, brings a number of benefits. It helps to understand whether key journeys leave the user in a positive emotional state; it recognizes areas that may elicit negative emotions; and it can help trying to counteract them with opposing, positive emotions. Most of all, they raise considerations about the emotional state of users even before they engage with the system. Attributing this method to the building of personas may be very helpful in assessing how well the system caters for each one on an emotional level.

Adding scoring to the wheel creates a simple and practical tool to work with. For most journeys it can be assumed that the user starts at an emotional state of 0, or neutral. Unless stated otherwise, the general implementation tries to make sure the user journey leaves the users in a better emotional state than when they started, or at least not any worse.

This process doesn't eliminate the need for research, but it can be used as part of a more conventional emotion mapping to see if the tasks are meeting the objectives of the user personas that have been created. They can also be used to understand the context of each persona prior to the interaction, based on the emotional value resulting from their journey until they meet the interaction point or load an application in their personal mobile devices.

A design framework

Despite all current development on data science, information science and user experience research, the majority of digital services still appear to their users via passive representations. It is not enough. The networked city cannot be fully understood in its potential until every infrastructure element is understood as a framework of active resources, each endowed with a structured, machine-readable presence, and the possibilities for interaction such provisions give rise to.

This framework takes into account three social powers that shape modern society —Citizens, Government, and Business sectors— while trying to build a growing interactive structure in order to enable most smart city stakeholders to a growing, information-rich environment. It consists of seven parts, ranging from '0', in which there is no knowledge whatsoever about environmental rules, up to '7', with complete awareness, allowing true participation from any citizen. The phases are:

0: NOTHING – The environment is unknown, usually ignored, taken for granted or dealt with traditional methods, generating close to no intelligence;

1: DATA COLLECTION – Data starts to be gathered, in structured and unstructured collections. There is little knowledge generated from the process;

2: STRUCTURED DATABASES AND PATTERNS – Stored in adequate formats, the data collected can be used by data scientists to gather intelligence and develop patterns. These databases are still complex for the general public;

3: VISUALIZATION – Dynamic data, gathered and processed in real time, becomes visible. This helps to identify multiple layers of information and subtle patterns. The information visualized is still passive;

4: ACTIONABLE INTERFACES AND FEEDBACK – Visualizations become interactive, giving users feedback on instant simulations of alternate realities;

5: SYSTEMS INTEGRATION – When many systems follow the same structured patterns, it becomes easier for cross -disciplinary patterns to emerge, allowing for complex analyses;

6: SCENARIO PLANNING AND FORECASTING – When most data are gathered and processed and stakeholders' ideas are taken into account, the city acquires a living interface; a dynamic service that can be appropriately malleable to accommodate very specific needs and requests, in a true collective environment; and

7: COLLECTIVE MANAGEMENT – The information gathered is presented in such a way that most citizens, from many areas of specialization, are able to customize and contribute to city management.

It is essential to strengthen the fact that people are not mechanical devices and their response towards a single scenario may deviate a lot from any average. The same condition that makes a young single student feel very comfortable can be upsetting, or even stressful, for an old couple. To help dealing with this situation, a "score" derived from Plutchik's wheel is to be added (and color-coded) to the description. A sample variation is shown below:

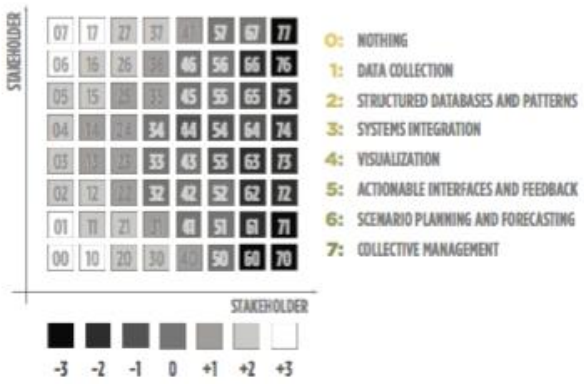

Figure 2: stakeholder relationships and degrees of emotional response.

To ease the collective perception of all phases involved, their stage, and how they are understood by each stakeholder, every step is to be assigned a value. This research suggests using hundreds for citizens, tens for government institutions, and units for business ventures. It begins, then, at a ‘000 -3’ scenario, in which no data is collected and everyone’s unhappy about it; and goes up to a ‘777 +3’ situation, when an integrated, interfaceable and actionable situation is accomplished in a way that pleases all parts involved.

The scenarios can be combined in a semitransparent cube, like this:

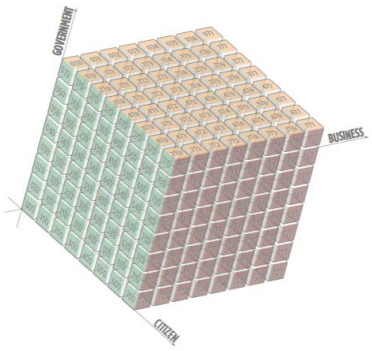

Figure 3: A cubic representation of the framework[21].

For instance, in a ‘500 +3’ situation one can imagine popular, hopeful, collective and integrated movements taking place; a ‘030+0’ regime raises suspects of a surveillance state, in which people are rather unaware of different realities, resulting in conformity; a ‘006 -3’ condition indicates a regime in which strong influence of corporations and lobbies over governmental institutions creates a frustrating environment. All mean dangerous imbalances, that could be eased with better information distribution.

The framework is designed to be scalable and robust enough to accommodate most of today’s businesses and public institutions, and to be held true even for products and services not yet invented. Its focus resides mainly on the relationships built among stakeholders, more than in technologies themselves. The cubic, colorful structure makes every situation and its surroundings easier to visualize, what helps to recognize future scenarios. Each face has its own color, shaded according to the level of emotion of each persona. When a specific context needs to be studied, the rest can be rendered

in a semitransparent way, allowing for better identification of the surroundings of the studied context.

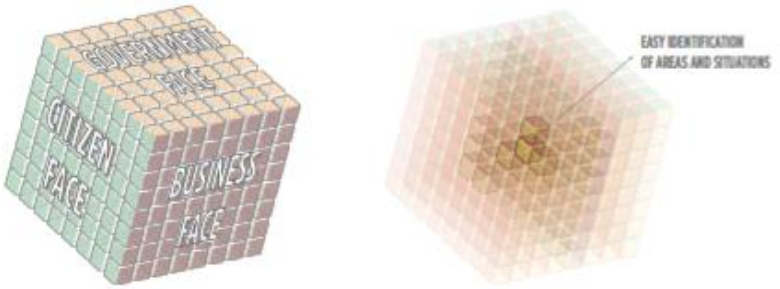

Figure 4: the three major stakeholders represented as cube faces for scenario identification.

It is not expected that all scenarios happen in a definitive form. The phases explained above are to be regarded as major guidelines, stages in which graphs may be plotted, in which the stakeholders and personas may behave as nodes, their changing role represented by a graph inside the cube:

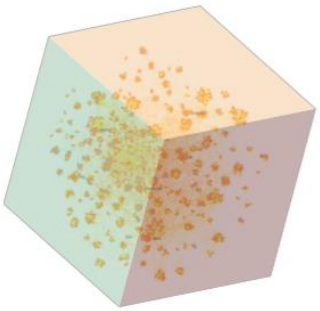

Figure 5: Graph inside the cube, representing variations inside a scenario.

This representation and the numeric code that follows it can be can be used to easily define very diverse situations, in a way that they can be easily grasped by multiple stakeholders, like:

404+2: Private Driver Networks[22] – digital startups and their users acting somehow free from government regulations, taxes and trade unions;

501+1: Occupy Wall Street[23] – people gathered using private networks and services to

[21] All diagrams and cubes were designed by this paper's author, and can be shared according to the copyright CC-ATT-ND (Creative Commons Attribution-NoDerivs 3.0 Unported).

[22] *Uber* is the best-known example of this category of services. It is a multinational online transportation network company that develops, markets and operates the *Uber* mobile app, allowing consumers with smartphones to submit trip requests routed to the company drivers. They act like independent contractors, using their own cars for the service and receiving a commission for the transportation fee charged. For more information, refer to < https://www.uber.com/our-story/ > retrieved on Oct 7, 2022

[23] The *Occupy Wall Street* was the name given to a protest movement that began in New York City's Wall Street financial district, receiving global attention and calling attention to social and economic inequality worldwide. Its main decision-making body and uses a modified consensus process, where participants attempt to reach consensus and then drop to a 9/10 vote if consensus is not reached, and so on. Information from

demonstrate against corporate greediness and government inaction;

404-2: The Arab Spring – similar to the 99% Movement, social protests in Arab countries happened with the help and support of social media companies;

050+0: Surveillance States – in which business and citizenship rules are not clear;

015-2: Weak states – suffering strong influence of corporation lobbies and informal organizations, ending up with little budget and liberty to effective rule their people

455+3: Private bicycle sharing – companies and the government gather citizen data in exchange for useful services;

466+3: Public universities – in partnerships with the private sector – the institution and the corporation gain from a partnership that fosters research; and

446+2: Smart grids – government and companies learn about user habits and are able to provide both infrastructure and consumer options to build a reliable distribution network.

Multimodal NUI Interfaces

A recent study[24] found that time online is spread across four device types (smartphones, tablets, PC/laptops, TVs). Many still relate the term to a flat, two-dimensional environment, filled with icons and windows, connected to a computer, keyboard and mouse. But the Graphical User Interface, or GUI, is only one kind of interface. A myriad of other systems is also common, despite little regarded, from the lights and sounds of a microwave oven to the auto focus and auto white balance of a digital camera.

In general terms, are considered 'interfaces' any tools or processes that allow for access, monitoring, translation or control of a system[25]. In digital environments they usually act as interpreters between computer systems (which only understand electrical pulses) and their users. Interfaces are channels with a symbolic[26] component, that often get mistaken with the system or machine it stands for.

Limiting the idea of interface to GUIs hat its positive side, by getting people closer to complex digital interactions in a way much friendlier than punched cards or command lines; but it also limited the number of interactions people believed were possible.

Wikipedia at < https://en.wikipedia.org/wiki/Occupy_Wall_Street >. More about the movement at < https://www.adbusters.org/occupywallstreet/ >

[24] Google and Ipsos' research *The New Multi-Screen World: Understanding Cross-platform Consumer Behavior*. August 2012, available at < http://www.ipsos.fr/sites/default/files/attachments/multiscreenworld_final2.pdf > retrieved on Oct 7, 2022

[25] According to the *IEEE Standards Dictionary Online*, available at < http://www.ieee.org/publications_standards/publications/subscriptions/prod/standards_dictionary.html > retrieved on Oct 7, 2022

[26] Many studies and essays explore the semiotic and symbolic aspects of user interfaces, like Clarisse Souza's 1993 *The semiotic engineering of user interface languages*, published in the *International Journal of Man-Machine Studies, Volume 39, Issue 5, pp.753-773, available at < https://www.sciencedirect.com/science/article/abs/pii/S0020737383710825 > retrieved on Oct 7, 2022*

The main task of user interfaces is to balance differences, which can be idiomatic (from analogical to digital, for instance, and vice versa), of operation procedures (like the ABS breaking system in a car) or even of speed (balancing response times between humans and machines). Its main goal is to stabilize most perception differences.

The conventional, desktop-based system follows a WIMP model, standing for "windows, icons, menus and pointers"[27]. While all WIMP systems use graphics as a key element (the icon and pointer elements), and therefore are GUIs, the reverse is not true. Some GUIs are not based in windows, icons, menus, and pointers. For example, most mobile phones represent actions as icons, and some may have menus, but very few include a pointer or run programs in a window.

Despite their sheer success and overall popularity, WIMP interfaces are not optimal for working with complex tasks such as working on large amounts of data simultaneously, or interactive actions. Many users with hard drives with storage spaces larger than 1 TB already have trouble finding random-named documents hidden in folders inside folders. Custom interfaces can better encapsulate workspaces, actions, and objects for specific complex tasks[28].

Some of the new, post-WIMP interfaces are called NUI, standing for Natural User Interfaces. They tend to ignore most traditional GUI and touchscreen standards on behalf of interaction patterns based on the physical world. Instead of buttons and menus, natural user interfaces are based on real-life objects and gestures. Instead of a mouse and a keyboard, they use multi-touch screens, cameras, microphones, pens, sensors e other devices that allow their users to interact directly with the interface, by using their hands, voice or body movements.

Multiple, combined interfaces should be built open to modification, adapting the interaction according to its presentation—the perceivable aspects, including media and interaction techniques, layout, graphical attributes; dynamic behavior— including navigation structure, dynamic activation, and deactivation of interaction techniques; and content—including texts, labels, and images.

[27] The origin of the term is uncertain, but its definition at Wikipedia is rather authoritative. Available at < https://en.wikipedia.org/wiki/WIMP_(computing) > retrieved on Oct 7, 2022

[28] The paradigm of WIMP interfaces can be considered rather outdated. Since Apple's popularization of the multi-touch screen with the iPhone, Interaction researchers are looking for new paradigms to represent human-machine interaction. ScienceDaily's 2009 *Human-computer Interaction: Beyond – Way Beyond – WIMP Interfaces presented some of the new forms of interaction being studied*. Available at < https://www.sciencedaily.com/releases/2009/07/090708083238.htm >retrieved on Oct 7, 2022

In a real-time city model, interfaces will be able to provide personalized streams of utility data, rendered into actionable information in order to make the city legible, understandable and more habitable. This kind of interface enables public services to be not only tune-able, but also tinker-able and hack-able, in clear opposition to the inflexibility and mono-functionality of contemporary cities.

It is important to remark that the urban interface should also be multimodal[29], concerning the identification of the most effective combination of various interaction modalities. In these systems there is usually a context manager able to detect events related to the user, technology, environment and social aspects; and an adaptation engine that receives the descriptions of the user interface and the possible adaptation rules. User interface requirements can be obtained through authoring environments at design time (best for kiosks and public displays) or generated automatically through reverse engineering tools at run-time (best for personal devices). When events associated with any adaptation rule occur, then the corresponding action part should be executed.

Usability in such environments is related to flow, measured in the time required by the migration process from the trigger on source device to the user interface presentation on target device. When this process is seamless it also tends to be anticipated: users should be able to predict target device, what interface parts are going to migrate, and where user's interactions results appear after migration.

It is important to consider that users often have short access time available, they may be on the move or able to pay limited attention to the interaction, therefore it is preferred to give access to small, actionable pieces of information in public spaces. For this reason, it is important to minimize text input and to keep consistency between platforms, so that the application knowledge acquired can be reused in a way that prevents user error and avoids overloading the interface with too many elements. It is also essential for such interfaces to behave discretely, being as unobtrusive as possible, in order not to raise the already substantial urban visual pollution.

Rather than making a city's services and networks appear seamlessly integrated

[29] For more on Multimodal User Interfaces please refer to SOEGAARD & DAM (EDS.) *The Encyclopedia of Human-Computer Interaction, 2nd Ed.,* chapter 39.8. Available at < https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/user-interface-design-adaptation > retrieved on Oct 7, 2022

or than making the connections between the deep levels of the urban protocol stack disappear, interfaces should highlight the seams that attach infrastructural networks between the layers of the urban stack, even among them and the social fabric, helping citizens to better understand how their societies work, and how the necessary tools to monitor and modify their operation can be developed.

Many important topics lay beyond the scope of this report and need consideration, such as How urban interfaces structure their inputs and outputs? How they illuminate and obfuscate various dimensions of the city? How they frame interaction? How that interaction both reflects and informs the relationship between citizens and cities? How these interfaces shape identities for urban citizens?[30]

The idea behind cities as interfaces is believing that people who face everyday problems usually spend a good amount of time dealing with them; and may have good insights to their answer. A bottom-up design, from and within the communities to the general city scheme can be useful to deeply understand the people it is looking to serve, and to create innovative new solutions rooted in their actual needs, while providing points of view and visceral experiences not typically accessible at street level.

The international design, innovation and consulting firm IDEO stated[31], in their publication devised to help social entrepreneurs in poor communities to develop collective change, that anyone can approach the world like a designer:

> [E]veryone is creative, creativity isn't the capacity to draw or compose or sculpt, but a way of understanding the world by making leaps, trusting intuition, and chasing solutions that haven't been totally figured out yet.

By continually iterating, refining, and improving urban work, more approaches can be tried, making it easier to arrive quickly at varied solutions that can lead to unprecedented strategies of problem solving. People, Businesses, and Government are the three principles of the success of a smart city initiative. Cities must study their citizens and communities, know the processes, business drivers, create policies, and objectives to meet the citizens' needs, in order to improve the quality of life and create real economic opportunities. This requires a holistic customized approach that accounts for city cultures, long-term city planning, and local regulations.

[30] Considerations to be regarded in subsequent studies.
[31] IDEO (2015, p. 19)

For too long, the international community has designed solutions to the challenges of cities without truly empathizing with and understanding the people it is looking to serve. But by putting ourselves in the shoes of the person we're designing for, urban designers can start to see the world, and all the opportunities to improve it, through a new and powerful lens.

A "Hundertwasserian" approach

Throughout his life, Austrian Architect Friedensreich Hundertwasser stood out as an opponent of the "straight line" and any standardization, expressing this concept in the field of building design. His individual architectural designs, despite being very peculiar[32], weren't considered by him as something finished, but a part of an evolving structure which imitates organic life.

In calling for creative freedom of building and the right to create individual structures, Hundertwasser considered human misery as a result of the rational, sterile, monotonous architecture. This was made clear in his 1958 "Mouldiness Manifesto[33]", in which he claimed *Window Rights*, meaning that

> A person in an apartment must be able to lean out of his window and scrape off the masonry within arm's reach. And he must be allowed to take a long brush and paint everything outside within arm's reach. So that it will be visible from afar to everyone in the street that someone lives there who is different from the imprisoned, enslaved, standardized man who lives next door.

Taking the idea of architecture beyond the design of physical structures and take it to the realm of dynamic systems and networks, it is easy to understand the Austrian architect's point of view. Built upon industrial, eighteenth-century values, urban metropolis are indeed rational, sterile and monotonous structures that make people miserable. From schools to institutions, NGOs to corporations, class associations to the federal government, almost all collective structures nowadays are still rigid and inflexible. Smart Cities should (and can) change it all.

References & Further reading

[32] They use irregular forms, and incorporate natural features of the landscape, in a way comparable to Antoni Gaudí (1852–1926) in its use of biomorphic forms and the use of tile. The Hundertwasserhaus apartment block in Vienna has undulating floors, a roof covered with earth and grass, and large trees growing from inside the rooms, with limbs extending from windows.

[33] Hundertwasser's *Mouldiness Manifesto* can be found at < https://www.hundertwasser.at/english/texts/philo_verschimmelungsmanifest.php > retrieved on Oct 7, 2022

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